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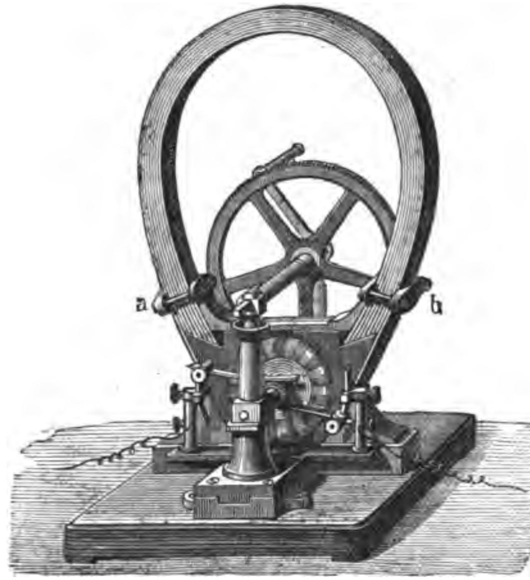

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PREFACE.

It is one of the leading advantages of all research in art and science that, although the difficulties or dangers in the pursuit may make the precise object unattainable, yet there is always something, however little evolved, that facilitates future art or scientific progress; the spirit of discovery survives all previous unsuccessful labours: and there is an unconquerable attraction in their very difficulties, if not in their actual impossibility of success. In looking back upon the past century of aeronautics, this will be found fully proved, for although the practical result may be but small, yet our stock of useful knowledge has been much enriched, at the cost of great labour and danger.

The employment of electricity as a motive power shows how closely men have followed a beaten track in this field. In early ages, when men knew nothing of any but animal power, flight was to be effected by means of our muscular strength. No sooner had the steam engine become a practical machine, than it was adopted by the aeronaut. The storage battery has scarcely become a marketable commodity, and flight is to be accomplished by its means. If some new agent or motive power were to be introduced to-morrow, it also would be resorted to by those who endeavour to make further improvements. It is time, to think,

that all such projects should be looked at from a common sense point of view; that is to say, from the point of view of competent engineers. This is the more necessary because the navigation of the air may after all not prove impossible. Who, indeed, can say what is and is not possible in physical science?

It is the intention in the following pages to ascertain and define, firstly, the obstacles which interfere with the active progress of ballooning; secondly, the mechanical means necessary to surmount them; thirdly, the natural power by which those means are to be put in operation;—and, lastly, to point out certain regulations and restrictions by which they must be governed in their application. The author has included as many historical data of the history of Ballooning as ascertainable, without encroaching too far on the technical portion.

Under what particular form these means may be applied, or whether indeed their application is within the reach of the powers placed at our disposal, is left entirely to the judgment and ingenuity of the reader himself to determine.

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BALLOONING.

CHAPTER I.

INTRODUCTORY.

THE pages of fabulous, as well as those of authentic history, present us with a variety of instances in which the art of flying has been the earnest desire of mankind in every country. Among the innumerable instances of the former we may call to mind the winged horses of the Sun, Juno's peacocks, and Medea's dragons; in the latter we find little respecting the real success of aërial experiments.

The limits of this publication not admitting of a thorough investigation of this art during the earlier ages, we shall briefly mention such circumstances as appear to be more particularly necessary, by way of introduction to the present system of Aerostation, and proceed with the narration of what is recorded relative to it. We shall omit all such circumstances as may appear trifling or absurd, and, on the other hand, state whatever may be worthy of mention or likely to be advantageous to future adventurers. Preparatory to this it may be necessary to observe that the attain-

ment of this object has only been attempted by two means, first, by giving motion to artificial wings, either by mechanical power or by the strength of man in imitation of the birds; and, secondly, by attaching the human body to something which, being lighter than air, might raise it into the vast expanse. The latter only of these methods has been verified by actual experiment; and in the following pages will be found a general outline of the state of that invention, which will hand to posterity the names of the discoverers and improvers of an art that may one day be productive of greater advantage.

The leading scientific men at the initiative of this new discovery of aërial navigation, seized the general idea involved in it, somewhat confusedly, but fundamentally in an effectually just manner. This idea has its starting point from **Archimedes**, two hundred years before our present era. The Syracusean geometrician discovered in the nature of fluids that the pressure which their own weight produces is distributed in an equal degree in every direction. For example, let us suppose a cube immersed in a fluid—water for instance—with its sides exposed to a certain pressure; the left side a pressure to the right, the right one to the left; the front, a pressure towards the back, the back towards the front; finally the upper plane a pressure directed below, and the lower one towards the upper.

What now concerns the two first pressures lies in

the fact of their being manifestly equal to each other, in direction, however, opposite; they therefore are null; and this applies to the third and fourth pressures, the cube being impelled to no side direction. It is different, however, with the two last cited pressures. The upper surface experiences a pressure downwards, the amount of which is determined by the weight of the column of water upon it; the higher this is the greater the pressure. The lower surface of the cube now lies in a greater depth than the upper, and upon it presses a greater column of water; certainly not directly above it, but around it on all sides; the whole fluid pressure is upon this lower side. This side is consequently driven by a greater force upwards than the upper is downwards. Whilst a cube is drawn downwards in vacuum by its full weight, it loses, as we may express it, in water as much of this weight as the displaced mass of water weighs. This is the Archimedean principle, and he who has moved at any time in such an element will have experienced this buoyancy, or lessening of his weight.

From what has been said we conclude that a body immersed in a fluid is borne so much more effectually, the less its surplus weight is over the displaced mass of fluid; and if it is lighter than this, it will not only be borne but lifted up; it rises in the fluid. It comes to this, that the body which is to swim may displace a good deal of water, itself possibly weighing but little, owing to a hollow form given to it. For swimming

in water, it is enough to fill this hollow space with air; and it may be open at the top as it is practically with our maritime vessels. It is different when it is to swim in the air, in this case the employment of a gas to fill the space is necessary, which gas may be so light that with its distended envelope it weighs less than the displaced air. Why then, we may ask, do we not make the hollow space completely empty?

This was the Jesuit **Lanis'** idea; however it is well that his proposal was not carried out, because the exterior air pressure would have immediately forced in his prepared copper balloon.

On the other hand, **Guzman**, taking up the idea, hit upon a substance, heated air, which fulfilled the desired object. Heat is known to expand all bodies, and to make gases specifically lighter.

When, therefore, the two brothers **Montgolfier** were the first, on the 5th of June, 1783, to impel a balloon upwards, it was by means of a wood fire placed at a lower opening of the balloon, giving them the merit of the first successful development of the Archimedean principle.

In the arrangement of their balloon they had not at all the right idea. They believed that through the fire, which was kept up below it, they could produce a new light gas, being led into this understanding by the analogy of smoke, from a wood fire, to a cloud, whereas the balloon owed its lifting force to the lighter heated air; an idea they were more enlightened upon after their

results had been in the meantime exceeded by others.

In the year 1766 Mr. **Henry Cavendish** ascertained that "inflammable air" was at least seven times lighter than common air; soon after which it occurred to Dr. **Black**, of Edinburgh, that if a sufficiently thin and light bladder were filled with "inflammable air," the bladder and air in it would necessarily form a mass lighter than the same bulk of atmospheric air, which would raise it up; but we lament that his other avocations prevented him from prosecuting this interesting experiment. This so-called "inflammable air" was what we now know as hydrogen gas.

The possibility of constructing a vessel, which, when filled with inflammable air, would ascend in the atmosphere had occurred to Mr. **Cavallo** about the same time; and to him belongs the honour of having first made experiments on the subject, in the year 1782, of which an account was read to the Royal Society on the 20th of June in that year. He tried bladders, but the thinnest of these, scraped and cleaned, were too heavy; he also tried China paper, but he found that the air passed immediately through its pores; and having failed of success, by blowing this air into a thick solution of gum, thick varnishes, and oil paint, he was under the necessity of being satisfied with soap bubbles, which being inflated with inflammable air, by dipping the end of a small glass tube, connected with a bladder containing the air, into a thick solution of soap, and

gently compressing the bladder, ascended rapidly in the atmosphere. These were the first kind of inflammable air or hydrogen balloons that were ever made.

But while the discovery of the art of aërostation was on the point of being made in Britain, it was all at once announced in France, from a quarter whence nothing of the kind could be expected; two brothers, **Stephen** and **Joseph Montgolfier**, paper manufacturers at Annonay, about twelve leagues from Lyons, distinguished themselves by exhibitiug the first of these aërostatic machines.

The first idea of such a machine was suggested to them by the natural ascent of the smoke and clouds in the atmosphere, and their design was to form an artificial cloud, by inclosing the smoke in a bag; the latter being lifted up by the buoyancy of the former.

The first experiment was made at Avignon, by **Stephen**, the elder of the two brothers, in November, 1782. The machine consisted of a silken bag in the shape of a parallelopipedon, the capacity of which was equal to 40 cubic feet: by applying burning paper to the lower aperture the air was rarefied and the bag ascended with rapidity to the ceiling. The discovery was made; and the reader may imagine the satisfaction it must have given to the inventor.*

Encouraged by their success, they constructed a

* See the Report made to the Academy of Sciences, December 23, 1783, signed by several Members.

machine the capacity of which was about 650 cubic feet; in the experiment it broke the ropes which confined it, and after ascending rapidly to the height of about 600 feet, fell on the adjoining ground. Shortly after this, they made another, of 35 feet in diameter, which rose about 1000 feet high, and fell at a considerable distance from the place from whence it ascended.

Omitting the various attempts and failures which the Montgolfiers made to attain their object, we finally arrive at their first public exhibition at Annonay, on the 4th of June, 1783, just over one hundred years ago. The balloon was made of linen, measuring 105 yards round, and on that occasion rose some sixteen hundred feet. This balloon was filled with a gas said by them to be half as heavy as ordinary air, but its exact nature they maintained a secret.

Professor **Charles**, however, a zealous pioneer in the same field, was not slow in seeking to discover the nature of this gas. He considered that as the experiment had been successful with a gas only half the specific weight of air, it would be better still with hydrogen, which weighs fourteen times less than air.

The progress of aeronautics would have been materially different, if the important discovery of hydrogen, the lightest of all elementary bodies, had not been made in 1766, by the Englishman, **Cavendish.**

This gas, Charles, professor of physics at the Conservatoire in Paris, determined to use in his aerial voyage

in company with Robert. The gas was but little known, and the property which had been recognised in it of being very ignitible was not calculated to inspire confidence; the principal point, however, was that hitherto it had been produced only in small quantities, by means of methods which manifestly were insufficient for an object that required the production of many cubic feet.

The most appropriate method for the production of hydrogen in large quantities for aeronautic purposes is by the treatment of fine particles of iron with acidified water, which being a chemical combination of hydrogen and oxygen, the oxygen may be separated from the hydrogen when a substance is submitted to it with which it has a closer affinity than it has to hydrogen. Such a substance is, for instance, iron; this, however, must be at a glow heat, if it is to decompose pure water. Others manage it differently by adding a powerful acid, for example, sulphuric acid; in this case the iron is capable, when cold, of effecting decomposition of the water. The deduction from this is that the protoxide of iron, which has a great affinity for sulphuric acid, arises out of the combination of the iron with oxygen, and this affinity favours its own production—a very interesting chemical fact. Therefore in the vicinity of the balloon to be filled, there are arranged large air-tight closed casks containing water and iron filings, each having two openings, one for the entrance of the sulphuric acid, the other for a hose through

which the hydrogen developed is to be conducted, and which unites with the small hose of the other casks to a large hose. With the object of cleansing from acid vapour, and for drying, the hose leads to an appropriate apparatus, such as always finds employment in the technic of manufacturing chemistry. The balloon on its part, which during the filling is held fast by stout ropes to posts, or by men, likewise continues, underneath, into a hose, and when both hose are placed in connection, the gas streams into the balloon, which was previously in folds, and now begins to distend it.

For the envelope a material must be chosen uniting great lightness with great closeness in the texture; consequent upon that the lighter a gaseous body is, the more minute and mobile are its smallest particles, and so much easier does it penetrate through its envelope. A material of little weight, completely impervious to hydrogen, is scarcely to be obtained; a relatively light silk stuff was deemed the best by the eminent savant Charles, who used it. It must, however, be covered over with a thick coat of varnish, the best is linseed oil varnish (Charles employed a resinous varnish); and, for the sake of greater firmness, the balloon is surrounded with a network composed of cords, which, hanging down to the lower half of the balloon, serve as support to the boat and aeronauts.

Professor Charles, by energy and patience, in a short time, scarcely three months after the first Montgolfier

ascent, employed the first so-called "Charlière," on the 27th of August, 1783. This attempt was a lamentable failure, for after the balloon had reached a height of three thousand feet in about two to three minutes, it was driven eastwardly by the prevailing wind, and, in consequence of a rent which the expansion of the gas had caused, fell at a village, and was torn to pieces with manure forks and flails by the peasants, who feared that this was a spirit to work them evil.

The first living beings which had the signal honour of leaving earth and going skywards in the boat of an aerial vessel, were a sheep, a hen and duck; and how delightful that journey, and how gentle the descent, may be inferred from the fact that the sheep was found eating when the balloon landed.

Notwithstanding some favourable experiments and better knowledge of this new aerial navigation, Louis XVI. had no faith in it, and would not sanction the experiment at the time when the enthusiast **Pilatre de Rozier** desired to make his first trial, but seriously, and somewhat cynically, proposed that two criminals, then lying under sentence of death, should ascend instead. However, Pilâtre succeeded in overcoming the king's sentiments, and obtained permission to undertake the aërial voyage himself—a step the king regarded as fraught with great peril. This first ascent was carried out on the 21st of October, 1783, by Pilâtre accompanied by the Marquis d'Arlander.

Some six weeks afterwards, professor Charles and

the brothers Robert followed in a "Charlière," named after the professor, and for some time afterwards, almost without intermission, the public were kept in a state of excitement with balloon exhibitions.

The "Charlière" had many essential advantages over the "Montgolfière," and it is not surprising it has driven the latter completely aside at the present time. In the first place it is much more secure: we may easily imagine how soon a fire kept up in the vicinity of such combustible material as taffeta might cause danger; in fact the number of accidents speak forcibly on this point. Hitherto, out of four to five thousand aërial journeys, there have been about thirty which have ended fatally, and of these the "Montgolfière" has to answer for more than twenty, which is the more significant because the far smaller proportion of journeys falls to its share.

Furthermore the "Charlière," filled with hydrogen, possesses a much greater lifting force than a "Montgolfière" of equal size; partly because the hydrogen is much lighter than heated air. The first in a pure condition is fourteen times, and even not pure, yet five to ten times lighter than air; the latter, on the other hand, even when the heating is carried as far as possible, is never more than half as heavy. We may easily arrive at the lifting force of these balloons of various dimensions by a speedy calculation; if we assume that the air in the "Montgolfière" during the process of heating is dilated about the third part of its volume, that

the hydrogen not pure, filling the "Charlière" possesses the seventh part of the air's weight, and calculating the square foot of the "Montgolfière's" envelope at an eighth and that of the "Charlière" at a twentieth of a pound, we arrive at results decidedly in favour of the latter.

Certainly very small "Montgolfières" may be made out of paper, possessing a considerable rising power, and turned to much enjoyment, but it is clear they are useless for serious purposes. A "Montgolfière" calculated to carry a boat and some men, must have, at least, fifty feet circumference, or about fifteen feet in diameter. A "Charlière," on the other hand, does this with half the size; and with equal size it is capable of carrying a four to five-fold weight.

Yet there is one important question to consider. Hydrogen is extremely costly in great quantities, and with limited means it has to be replaced with another and cheaper gas which is lighter than air. Such a gas is that made from pit coal, illuminating gas, in the discovery of which the Frenchman **Lebon**, the Englishman **Murdoch**, and the German **Winzer** contend for the honour, and which was employed by **Green** twenty years later in his aërial navigation. Illuminating gas, however, is much heavier than hydrogen, and on that account reduces the lifting force of a "Charlière" by one half to one third. Yet from what has been said previously, this force is always sensibly greater than that of the "Montgolfière." The carrying force of the former,

with illuminating gas, may be taken at twenty-one hundredweight, with a balloon of fifty feet diameter, and could, therefore, carry ten to twelve men, besides the boat and requisite materials.

Moreover, in all these considerations and calculations, one has to reflect that they are only available, at least strictly so, for the air strata immediately over the surface of the earth. In ascending, the air is recognisable—a consequence of the earth's attraction—as always lighter and lighter; and at the summit of Mont Blanc, it is, for instance, only half as heavy as at the sea level. As the rising force of the balloon is dependent upon its lesser weight, compared with the displaced mass of air, there necessarily follows that it must be continuously less the higher the balloon ascends. There is consequently a certain boundary beyond which no air craft can pass, and this boundary lies the lowest for the "Montgolfière," and the highest for the "Charlière" filled with hydrogen. The circumstance that the balloon in ascending comes gradually into more rarefied air strata necessitates besides, where hydrogen is employed, a precaution, the neglect of which in early periods led to serious results.

As the balloon attains more and more rarified strata, the outside pressure to which it is exposed becomes less and less the higher it rises; the envelope, on the other hand, experiences from within a continuously increasing pressure: a condition at-

tended with much risk, if beforehand means be not taken by using a less volume of gas so as to allow for the inevitable expansion of the balloon in the higher regions.

CHAPTER II.

FIRST PRACTICAL EXPERIMENTS.

In this island, where the improvements of art and sciences find their nursery, and many their birth, no aërostatic machine was seen till about the close of the year 1783, when Count Zamberrari, an Italian, performed the first experiment in London on the 25th of November. His balloon was constructed of oiled silk, ten feet in diameter, and weighed only eleven pounds. Three quarters of it were filled with hydrogen; a direction, for any person who should afterwards find it, enclosed in a tin box, was fastened to it, and in presence of many thousand spectators, it was launched from the Artillery Ground at one o'clock in the afternoon.

At half-past three it was taken up at Graffam, in Sussex, a distance of 48 miles from London, so that it went at the rate of nearly 20 miles an hour.

A balloon of some four feet and a quarter in diameter, and filled with hydrogen, was floated, on the 22nd of February, 1784, at Sandwich, in Kent. Impelled by a north-west wind, it crossed the Channel rapidly, and was found in France, in the country, about twelve miles from Lille. To this balloon a letter was attached begging the finder to inform

"William Boys, at Sandwich" the place and moment it was found.

Mr. **Tyler** is the first person in Great Britain who navigated the air. He ascended at Edinburgh on the 27th of August, 1784, and descended quite gradually about half a mile from the place where he rose.

Vincent Lunardi, a native of Italy, and secretary to the Neapolitan ambassador in London, made his first aerial voyage in England, on the 15th of September, 1784. His balloon, thirty-three feet in diameter, was made of oiled silk, painted blue and red. From a net, which covered about two-thirds of the balloon, descended forty-five cords to a hoop hanging below the balloon, to which the gallery was attached.

The balloon had no valve, and its neck, terminating in the form of a pear, was the aperture through which the hydrogen was introduced, and through which it might be let out. The gas for filling the balloon was produced from zinc by means of diluted sulphuric acid.

Mr. Lunardi departed about two o'clock, and with him were a dog, a cat, and a pigeon. After throwing out some sand to get clear of the houses, he ascended to a great height; at about half an hour after three o'clock he descended very near the ground on the common of South Mimms, where he landed the cat, which was almost dead with cold; then rising again, he prosecuted his voyage. He ascribes his descent to the action of an oar, but it was more probably occasioned by the loss of hydrogen.

At ten o'clock he descended in a meadow near Ware, in Hertfordshire. His principal care was to avoid a violent concussion at landing, and in this he fortunately succeeded.

His thermometer, in the course of his voyage, stood as low as 29°; and he observed that the drops of water that collected round the balloon were frozen.

Mr. **F. Sadler**, on the 12th of the preceding September, about three days before the experiment of Signor Lunardi, had made an ineffectual attempt to ascend in a "Montgolfière," from a retired spot in the neighbourhood of Shotover Hill, near Oxford, which was frustrated by the accidental combustion of the balloon almost immediately after it had quitted the earth. Had it not been for this untoward accident, a foreigner would not have had to boast the honour of having accomplished the first aerial voyage ever undertaken in England.

However, on the 12th of the following month, Mr. Sadler really ascended and alighted safely at Hartwell, near Aylesbury, which is about fourteen miles from Oxford; which length he travelled in seventeen minutes, so that he travelled at the rate of nearly fifty miles an hour.

Mr. **Sheldon**, professor of Anatomy to the Royal Academy, is incorrectly mentioned as the first Englishman that ascended with an aerostatic machine. He ascended with M. Blanchard, from Little Chelsea, on the 16th of October.

Argand, of Geneva, the inventor of the chimney-glass lamp with double current of air, about this time exhibited before the King, Queen, and Royal Family, at Windsor, the ascent of a balloon filled with hydrogen. It was very small—only three feet in diameter.

At this time, in 1784, **Blanchard**, subsequently so celebrated in aeronautics, made his first ascent at Paris.

Before the discovery of the balloon, Blanchard, who had a mechanical genius, invented an apparatus to navigate in the air—an atmospheric machine armed with oars, and with which he sustained himself in the air at an altitude of eighty feet. The discovery of the balloon determined his researches of this kind, and him to become an aeronaut.

His first ascension in the Champ-de-Mars took place on the 2nd of March, 1784.

Blanchard rose above Passy, and descended in the Plain of Billancourt, near the manufactory of Sevres. He was only one hour and a quarter in the air.

This short ascent was marked with a curious circumstance. Everyone knows now that a balloon ought never to be entirely filled at the moment of departure. It should be only about three-fourths filled. It would be dangerous to fill it completely, for in proportion as it rises the atmospheric strata diminishes in density, and hydrogen in the aerial vessel acquires more expansion

in consequence of a decrease in the resistance of the exterior air. The sides of the balloon would then give way to the pressure of the gas, if an outlet is not provided for it. Consequently the aeronaut observes with much attention the state of the air craft, and when its sides indicate a great expansion of the interior gas, he opens the valve and allows the gas to escape. Blanchard quite ignorant of the laws of physics, did not observe this appearance. His balloon rose, swollen out of proportion, and the imprudent aeronaut did not comprehend his danger. The sides of the balloon strained in all parts; they were on the point of bursting. Blanchard, who had reached a considerable height, ceded less to the consciousness of danger which surrounded him than to the impression of fear caused by the immensity of the gloomy, silent regions to which the balloon had so suddenly transported him. He opened the valve to descend again, and this terror drew him from a peril into which his ignorance was on the point of placing him.

Blanchard boasted having ascended thirteen thousand feet higher than any of the aeronauts who had preceded him, and he maintained he had directed his balloon against the wind by the aid of his governor and oars. The scientists, who had observed the aerial craft from an elevated spot, contradicted his assertion and published a statement that the alterations in his progress were entirely owing to the currents of air he had met with. He had written upon the tickets of admission

this high sounding motto : *Sic itur ad astra,* which gave rise to the epigram,

> "Au Champ-de-Mars il s'envola
> Au champ voisin ; il resta là.
> Beaucoup d'argent il ramassa.
> Messieurs, Sic itur ad astra."

The zeal of aeronauts and savants did not relax. Every day was marked with an ascension.

Emboldened by the success of his first voyages, Blanchard then conceived a project, the boldness of which, at this epoch, when the science of aeronautics was still in its infancy, amounted to madness. He wished to cross the Channel in a balloon. This adventurous passage was only to be effected with great danger, and, assisted by several most fortuitous circumstances, the principal one being the continuance of a favourable wind always directed towards the French coast.

This bold venture was attempted on January 7, 1785, by Blanchard, accompanied by Doctor Jeffries.

The weather was calm with a north-westerly wind. The balloon was filled with gas close to a steep rock, from which could be seen the precipice so graphically described by Shakespeare, in King Lear. At one o'clock the balloon was left to itself, but, its weights being found too heavy, it was necessary to throw away a part of the ballast, and only to keep thirty pounds of sand. The balloon rose slowly and drew towards the sea, impelled by a light wind.

The voyagers had then under their eye the beautiful country stretching out behind the town of Dover. The view embraced an horizon so extensive that they could count thirty-seven centres of population. On the other side, the steep acclivities which border the shore and against which the sea hurls its waves. Now being above the sea, they passed over several vessels in full sail far below. As they advanced the balloon began to descend a little, and at half past one it was visibly falling. In order to rise again they threw out half of their ballast. They were then about one third of the distance and could not distinguish Dover Castle. The balloon continued to descend and they were forced to throw out the remainder of their store of sand, and, this lightening not being sufficient, they got rid of some other weight in the boat. The balloon then rose and continued to sail before the wind towards France. They were then about half way on their perilous voyage.

At a quarter past two the rise of mercury in the barometer told them the balloon was beginning to fall again. They then threw out some tools, an anchor and some other things they had provided themselves with. At half past two they had reached three fourths of their journey and they began to perceive the coast of France, to which their eyes had been strained for some time to catch a glimpse.

At this moment the balloon was falling from the loss of gas, and the aeronauts saw with fright that it was descending with a certain rapidity. Frightened at the

thought of falling into the sea, they hastened to get rid of everything that was not absolutely necessary for their safety, and they threw away their stock of provisions. The rudder and oars, useless weight, were cast into space; the ropes went with them as well as their heavy clothing.

In spite of all this the balloon continued to fall.

Nevertheless, a last and perilous resource remained, they could get quit of their boat and fasten themselves by the cordage of the balloon. They were on the point of carrying out this resolution and had secured themselves to the cordage netting, ready to cut the ties which held the boat, when they felt a movement of ascension; the balloon in fact was remounting. It continued to ascend, regained its road, and the wind being favourable, they were impelled rapidly towards the coast.

Their terror was quickly forgotten as they distinctly perceived Calais, and the outline of the villages which are above it. At three o'clock they passed over the town, and at last fell in the forest of Guines.

The balloon rested on a large oak, a branch of which the doctor seized and their progress was arrested. They opened the valve, the gas escaped, and thus the fortunate aëronauts were safe and sound from the most exhausting undertaking that the temerity of man may have at this time imagined.

The next day the success of this event was celebrated at Calais by a public fête. The Fre

flag was hoisted before the house where the aëronauts slept. The municipal body and officers of the garrison came to pay them a visit. At the end of a dinner given to them at the Town Hall the Mayor presented Blanchard, in a gold box, with the papers of citizenship of the town of Calais. The municipality bought from him, for £240 and a pension of £25 a year, the balloon which had thus carried him across the Channel, and which was deposited in the principal church in Calais.

Some days after, Blanchard appeared before Louis XVI., who granted him a gratification of fifty pounds and a pension of a like sum.

The fitful life of this brave aëronaut was further illustrated by the brief enjoyment of his pension of fifty pounds a year. The upheaving of the whole fabric of state, and the political and social revolution, followed by the decapitation of the good king and that of Marie Antoinette, swept away his pension amidst the general wreck.

The great success of Blanchard was the cause of many attempts of the same perilous character; for the honours and fame acquired by the fortunate aëronaut dazzled the eyes of a great number; among them may be named **Pilatre de Rozier**, an enthusiast for the new art. He had previously announced his determination to attempt to cross the Channel, notwithstanding the strong advice given him by scientific friends to desist from such a hazardous experiment.

He assured them he had discovered a new system of aërial vessel which united all the conditions necessary to security. Upon these conditions Government granted him a sum of forty thousand francs (£1,600) in order to enable him to construct his aerial craft.

The public then learnt what was the combination he had imagined.

He united in one system the two means which had been previously employed.

Below a balloon with hydrogen he had joined a "Montgolfière."

Whatever his reason was for combining these two systems is not exactly known, of which, each isolated, has its advantages, yet joined together offer the most objectionable combination. It was only too easily understood how a fire in the vicinity of an inflammable gas, such as hydrogen, exposed the aëronaut to fearful danger: "You are placing a lighted torch under a barrel of powder," said Professor Charles to Pilâtre de Rozier; but the latter would not hear reason.

As he required help in order to construct his balloon, he applied to an inhabitant of Boulogne, named **Pierre Ange Romain**, formerly solicitor in Rouen and Commissioner of Excise, a post he had just given up. This Romain, associated with his younger brother, began to construct, in one of the rooms in the Tuileries, the balloon that was to carry him and Pilâtre.

An agreement of partnership was concluded between these two on the 17th of September, 1784.

The ascent was publicly announced to take place on the 1st of January, 1785, and the balloon was deposited in the bath establishment, called now Hôtel des Bains. But the ascension did not take place at the appointed period.

Pilâtre set off for England, leaving Romain at Boulogne. He went to Dover, doubtless to see Blanchard.

Pilâtre returned to Boulogne on the 4th of January, and it does not appear he thought of executing yet the voyage publicly announced. It has been previously stated that Blanchard, setting off on the 7th of January, 1785, fortunately accomplished the passage of the Channel. Thus Pilâtre was anticipated.

He travelled immediately to Paris, where he arrived at the same time as his fortunate rival. He came to confide his fears to M. Calonne, but the minister received him very ungraciously.

"We have," said the minister, "expended one hundred thousand francs (£4,000) on your balloon in order to enable you to cross the Channel, and you must do so."

Pilâtre returned to Boulogne with the order of Saint Michel and the promise of six thousand francs (£240) per annum pension in case of success, but he was filled with gloomy forebodings.

On the 21st of January he installed on the esplanade,

the chemical apparatus necessary for the preparation of the hydrogen, and the gasometer required to collect it was placed under some tents along the ramparts.

But days and months passed without anything being done, and postponements were frequent from one cause or another, principally owing to the adverse currents of air. In the meantime the funds granted were exhausted, and Romain was in debt to the extent of eleven thousand francs for the construction of the hydrogen balloon, and he owed three thousand five hundred francs for the "Montgolfière." His creditors pressed him and went so far as to threaten to seize the balloon. Romain sent the creditors to Pilâtre and they demanded their money, and Pilâtre referred them to the minister, who turned a deaf ear to their applications.

The embarrassments of Romain went so far that he was on the point of quitting the town for some foreign country to escape from his difficulties.

The frequent postponements of the ascent led to skits and satirical verses, and public posters exhibited Pilâtre in caricature.

Pilâtre could not withdraw from his engagement with the public and the Government. He was held to give an account of all the sums he had received from the minister. On the other hand his creditors did not cease to press him. The author of the "Annèe Historique de Boulogne" affirms that when Pilâtre and Romain set off on their aerial voyage across the

Channel they were cited to appear the next day before the judges for payment of a bill of 383 livres which had been owing three months.

On the 15th of June, 1785, at seven in the morning, Pilâtre de Rozier and Romain repaired to the coast of Boulogne, in order to effect their departure in the "Aëro-Montgolfière." Three trial balloons were first sent off to ascertain the direction of the wind, and then the discharge of a cannon announced to the town the moment of their departure.

The Marquis de Maisonfort wished to accompany them. He cast into the hat of Pilâtre a rouleau of 200 louis and placed his foot in the boat, but the aeronaut gently pressed him back, saying, "I cannot take you with us, for we are not sure of the wind, nor of the air-craft, and we only desire to risk our own lives."

Maisonfort, fortunately for himself, remained a simple spectator of the departure, and it is to him we owe the exact account of the drama enacted under his eye.

The causes of the catastrophe which cost the lives of the two brave aeronauts, are enveloped in a certain mystery. The nobleman alluded to gave the following explanation :—

The double aerial vessel, that is to say, the "Montgolfière," surmounted by the balloon filled with hydrogen, rose with very great velocity to a height of about thirteen hundred feet; but at this height he saw the

balloon collapse and fall down almost immediately upon the "Montgolfière," when this turned over three times; dragged by this weight, it immediately descended with frightful velocity.

Furthermore, according to this nobleman, what happened was as follows:—

A few minutes after their departure the voyagers were assailed with a contrary wind, which threw them towards land. It is probable that, in order to descend and seek a more favourable current of air which might lead them on to the Channel, Pilâtre de Rozier pulled the valve of the balloon, but the cord attached to this valve was very long—it was not less than one hundred feet, as it passed from the boat placed below the "Montgolfière" up to the top of the balloon—it consequently acted with difficulty. The very severe friction which it occasioned tore the valve. The material of the balloon was weakened by the great number of preliminary trials which had been made at Boulogne, and several attempts at departure. It was torn near the valve and the rent extended over many feet; the valve fell inside and the balloon was emptied in a few moments. There was, therefore, no inflammation of the gas (as has been repeatedly stated) when suspended in the atmosphere. It was noticed after the fall that the stove under the "Montgolfière" had not been lighted. The real cause of the tragedy was in the balloon being emptied of its hydrogen, falling over the "Montgolfière," and the weight of the whole mass being dragged with

terrible velocity to the earth. The Marquis de Maisonfort ran toward the place where the balloon had just fallen. The unfortunate voyagers had not even passed the shore and had fallen near the market town of Vimille, the same spot where Blanchard had landed, not far from the column erected to his honour by the French people.

The death of Pilâtre and Romain silenced all traces of satire and envy. It created an universal sympathy for them, and with a feeling, too, that they were forced into their hazardous experiments by the pressure put upon them financially and otherwise, through the action of several of the French people themselves.

Aërostatics became by-and-by universally popular, from prince to peasant. Scarcely a day passed without a balloon ascent in one place or another, of the "Montgolfière" type. Few attempted the perilous journey, but were satisfied to launch the harmless "Montgolfières" or the aërial vessel filled with hydrogen.

CHAPTER III.

RESOURCES AND INCIDENTS.

Aeronautics have to do with two essentially different and difficult problems. The first problem is the voluntary movement on a vertical line up or down. This problem found its solution partly in the first years of the discovery of the art, and since then, in a certain degree, completely. As concerns the "Montgolfière" it lies in the stoking and interruption of the burning fire below the opening of the balloon. Stoking the fire promotes the expansion of the air, and imparts a renewed rising force to it, whilst the interruption of this causes the air to become cold and to condense, and thus the balloon sinks. This process may be continued as long as the fuel lasts, a contingency of uncertain duration that must terminate so much sooner the more frequently the fire is stoked. It is clear that if to burn a flame below a balloon is difficult, there is so much the more danger in stoking and slacking the fire, during the continued oscillations to which the balloon is subjected in the region of the air; and that the least accident from the merest spark would result in the destruction of the entire air craft is a self-evident fact. No wonder, then, that the "Montgolfière" in our time has almost disappeared from the domain of

practical use, and now merely enjoys an historical name.

Much safer, although not entirely free from danger, are the means employed in the "Charlière," whether it is filled with hydrogen or illuminating gas, so as to go up or down at will.

The first ascent made by it had a favourable result, as we have previously noted, through the lesser weight in comparison with that of the air mass displaced by it. In consequence of this lesser weight, even if it were a minimum, the "Charlière" would rise without ceasing until reaching the highly rarified air of the upper region. Now, here the aërial vessel is in equipoise with the surrounding atmosphere; it floats in these heights without rising or falling. For example, the lesser weight of the fully equipped balloon, including boat and men, amounted at the moment of rising to ten hundredweight, making a total weight of fifty hundredweight. Thus it reaches a height of four thousand five hundred feet into a condition of equipoise, because the weight of air here is only five-sixths of that on the earth's surface, therefore instead of sixty hundredweight (50+10) it is then only fifty, the weight of the air craft is strictly equal to that amount of the surrounding atmosphere it displaces.

If the aëronaut now wishes to mount higher, no other means are left than to lessen the weight of his craft so as to restore again its lesser weight. Towards this object the sand taken in large bags at the time

of starting is usefully employed. Naturally, this ballast now prejudices the ascent of the balloon, yet its weight would do no harm if it only leaves a certain lesser weight in the air craft in comparison with that of the atmosphere. At the same time we may perceive how the aëronaut with the help of these sand bags can keep himself afloat within certain limits, in every altitude.

If the aëronaut, on the other hand, wishes to descend into a lower air strata, he makes the balloon heavier by a new weight from without. For this purpose the valve in the upper part of the balloon, usually held closed by a spring, is employed at the proper moment by means of a draw rope reaching into the boat and enabling the aëronaut to open the valve. He can thus let off a greater or lesser part of the inclosed gas, and so change the lesser weight of the balloon into a greater over-weight. The employment of ballast as well as that of the valve takes its source from Professor Charles; and the first "Charlière" which ascended with human beings was provided with both arrangements. However, the valve must be worked with great caution, so as not to fail in its action under such difficult circumstances as altered atmospheric pressure in an atmosphere moist through clouds and mist. Sometimes it cannot be sufficiently opened, and the proper place for descent is missed. Sometimes, which is the worst case, it is opened and cannot be closed again, and the gas escapes so violently that

the collapsing balloon falls down with immense velocity. This happened to the celebrated aëronaut Coxwell, when he, with several others, made an ascent at night, and it was only by the sacrifice of every apparatus and instrument, as well as their heavy clothing, and aided by a coincidence of favourable circumstances, that the travellers were indebted for their escape.

Regarded from the practical point, ballast and valve afford a tolerably perfect means by which to sink or rise voluntarily. Experienced balloonists control these two helps with such exactness that they are enabled to choose within a few yards a desired position in which they wish to float; a most important point. In one respect, however, both methods, the ascent as well as the descent, are very imperfect, or rather their combination. In the empire of nature a distinction is made between the *reverting* and *non-reverting* processes. The elevation of a weight to any height is an example of a reverting process, because the weight can again return to the lower place; the combustion of coal on the other hand is a non-reverting process, because out of the ashes it is not possible to regain the coal again by any direct method. If, therefore, we imagine the stoking and slacking the fire under a "Montgolfière" to be two opposite processes not equal in their effect, in the slacking the coal employed in the stoking is not regained, the store of firing gradually melts away; when it is used up

the aërial journey has necessarily reached its termination.

Similarly circumstanced are the two processes which effect the up and down movement of the "Charlière." The throwing out of ballast, as also the letting off the gas, are not revertible processes; the ballast as well as gas once sacrificed is irretrievably lost to the aëronaut; and, therefore, the mobility of the air craft, in a vertical direction, is restricted within temporary limits.

This has caused inventive heads, at an early date, to ponder over other means, so as to attain the same object by uniting two opposite processes, of which the one is the reverse of the other. Of these discoveries two deserve to be prominently named, one of the period in which aëronautics take their initiatory start, by **Meusnier**, and a second by **Joule**, during the last siege of Paris.

Meusnier brings to the gas balloon proper a second balloon, either inside of it or placed about it, and filled with air, as well as provided with an arrangement by means of which it may always be placed in connection with the exterior atmosphere.

Joule, on the other hand, instead of ballast in the boat wished to employ a metal reservoir, the sides to be strong enough to resist any important interior pressure, and by means of a hose and pump to be brought into connection with the balloon. If, now, gas is pumped out of the balloon into the

receiver, then the envelope of the balloon gives a little, collapses somewhat, and the balloon is relatively heavier and sinks; on the other hand, if the gas is allowed to stream back out of the receiver into the balloon it ascends again. During the siege of Paris good results were derived with this aërial vessel, and it is not shown why this plan has not been further adopted.

Our reflections on the movement of air craft in a vertical direction ought not to be concluded without naming two arrangements which refer to the landing of the aëronaut. The first of these arrangements, the anchor, may be dismissed in a few words. It is thrown out where the aëronaut intends to break his voyage and is but little different from a ship's anchor, only care must be taken in employing it, that it, as well as the cordage by which it is let down, involves as little weight as possible, so that it may not overbalance the craft. This is so much the more important as every prudent aëronaut takes several anchors with him, in order not to be entirely without the means of landing in the event of one anchor being lost.

The other arrangement, the parachute, has essentially an historical interest. After it had remained for a long time the centre of all interest in the promotion of aerial flight, it is at present, although not completely, in a state of oblivion. This parachute arrangement is for the object of affording protection in sudden unforeseen cases of irregularity in the balloon.

The idea of the parachute has been developed inde-

pendently of that of the balloon. In the year 1783, the year from which we date the invention of the balloon, Professor Lenormand instituted experiments connected with the parachute. On the 26th of November of that year he let himself down from the first story of a house in Montpélier, holding in each hand a large umbrella. The velocity of his descent was very small, and he alighted on the ground with a very slight shock; repeated experiments confirmed the favourable result.

It is known that all bodies, falling in vacuo, descend with equal swiftness, a leaden ball not more quickly than a bit of paper. In atmospheric space, on the other hand, the resistance of the air prevails in a double sense: first, as frictional resistance in so much higher degree the more surface the falling body offers to the air, therefore the surface of the distended material must be as large as practicable; secondly, as so-called motion resistance, in so far as the falling body is compelled to push before it a certain mass of air, which cannot itself escape quickly. The parachute must, therefore, have underneath a form as concave to the earth as practicable, because the air is thus better caught, and its escape rendered the more difficult.

Montgolfier added a parachute to his balloon, which opened whilst descending.

It became really a passion to descend with a parachute. The hare-brained Madame Garnerin ended her aerial voyages with it, leaving the balloon and

coming down with the parachute. Eye witnesses assert that she shot out of the balloon with lightning speed, trusting to the yet unopened parachute, but which always opened itself quickly, placing her gently on the ground. The saving of life in unforeseen danger is largely due to the parachute, but with the security now afforded by ballast and valve its employment is too often omitted.

CHAPTER IV.

THE PRACTICAL APPLICATION OF AERONAUTICS.

AMONG the uses of aeronautics are some for which the mobility of a balloon in a vertical direction is particularly suited.

Before all, is the application to scientific research. The aeronaut finds himself in this respect in a much more favourable position than the mountain climber. He has neither to submit to the exertions to which the latter is exposed, nor is disturbed by the vicinity to the earth to which the pedestrian is always restricted.

Scientific balloon voyages have not merely contributed to confirm our ideas concerning the nature of the atmosphere surrounding the terrestrial globe, but also in many respects to enrich that knowledge.

Among the instruments which the aëronaut requires, the barometer is the most important. Not only because it gives the atmospheric pressure at the place where the balloon is, but because it also offers the only possibility of calculating from this atmospheric pressure, the height at which the aircraft is at any moment. It also shows every instant whether the balloon is rising or falling, according as the mercury falls or rises. The aëronaut also learns this with certainty when he throws out bits of

paper and observes whether they remain below or above; a means also employed to ascertain whether the movement is in a horizontal direction or not, in the case when the surface of the earth is no longer visible.

With the help only of thermometrical observations at places on land of known height, the exact law, of decrease of temperature of the air, in the higher regions is not yet, however, fully established. **Saussure** has endeavoured to fix it by comparative observations, taken upon land and high mountains. Other experiments by different physicists have added to the store of facts without confirming any exact rule. According to Saussure's experiments, the temperature of the air is lowered one degree at an elevation of four hundred and twenty to four hundred and fifty feet. On the other hand, observations taken on the Pyrenees give one degree lower for three hundred and seventy five feet; finally **Gay-Lussac** found the figure one degree for five hundred and twenty feet. If we take the mean of these three statements we find it to represent within a fraction, four hundred and forty eight feet for one degree. **Barral** and **Bixii** in their aërial navigation noticed, they said, a decrease of thirty-nine degrees at an elevation of eighteen thousand feet. It is most probable, however, that future observations at high altitudes may converge to establish a fixed law of the decrease of atmospherical temperature.

We are equally in the dark as to the exact decrease

of density of the atmosphere. The positive figure representing the decrease of density according to the elevation, depends upon the decrease of temperature, and the decrease of barometrical pressure. Physicists, with good reason, do not agree with Biot's opinion relating to the rate of decrease in the density of the air, as the law has only been based upon some four or five observations of Humboldt and Gay-Lussac.

If this law of density were firmly established, we should possess a certain method of measuring the heights of the atmosphere surrounding the earth, and consequently its physical limits.

Barral and Bixii deduce from their ascent on the 27th of July, 1850, the following table of decrease in atmospheric pressure and temperature.

Barometer in Millimetres.	Calculated height in Metres.	Temperature. Fahr.
695	757	39°
675	999	39
656	1244	32
637	1483	24
598	2013	21
559	2567	21
482	3751	2·75
357	6116	·24
338	6512	·86
315	7016	·95

This inexactness of our knowledge is all the more perplexing as the aëronaut is compelled to take note

of all the circumstances surrounding his position; not only, as has been said, for exact determination of the heights he finds himself at, but also not to lose sight of the lifting force of his vessel. What importance the decreasing density of the air has, we have had many illustrations.

Besides, aeronauts must have been compelled to feel personally the effect of a decrease of pressure and density of the air. Not only the action of breathing is very much oppressed, which often causes unconsciousness, but a serious disturbance of the equilibrium between the outer and inner pressure upon the vessels of the human body occasions an extraordinarily increased pulsation. **Biot** counted one hundred and eleven pulsations at a height of sixteen-thousand feet, whilst before the ascent his pulse numbered only seventy-nine. When the air pressure decreases still more, the vessels of the body are so severely tested that blood issues from the nose and mouth. At a height of eighteen-thousand feet the air is only half as dense as at the earth's surface; and at thirty-thousand only a fifth. At the latter height man is able to live only a few seconds. Some years ago, the aeronaut Tissandier probably was the first who ascended higher and became a sacrifice to that forbidden region.

Aëronauts have opportunities of seeing the heavens almost in the colours in which we would see them, were it not for the thick atmosphere near the earth's surface, which is only very imperfectly transparent. The more

rarefied, or thinner the air is, the brighter the stars shine in clear weather, and so much deeper black is, what to us is a blue sky. To the unsuitableness of a stay in these heights, there is added the Siberian cold which rules there, independent of all time of day or year. Neither midday heat, nor heat of the sun, do we owe to the direct rays of that luminary, but to the earth which catches up these rays and through air stratum to air stratum passes them upwards.

The further now these air strata are distant from the surface of the earth the thinner the air in them becomes, and consequently so much weaker is the continuation of heat. Among the aerial voyages confirming this fact, the most interesting is that of Barral and Bixii, at Paris, on the 29th of June, 1850. It was purely for scientific observations that these two aeronauts, one a former pupil of the École Polytechnique, the other a doctor of medicine and scholar, undertook the ascent. Provided with perfect instruments, their object was to ascend to a great height, in order to study several meteorological phenomena, imperfectly observed previously. At first the temperature fell very slowly, then continuously more quickly until about twenty-two-thousand feet high, it reached its lowest condition, and in descending again, the temperature rose with the same regularity.

The balloon initially ascended in a light fog, gradually pushed through cloud strata into a compact thick mist of "ice needles," until at last the heavens above

were serene, and the beautiful spectacle of the reflection of the sun below the actual figure was impressive. All these changing circumstances naturally influenced the action of the thermometer. In every case the temperature in the higher altitudes was observed to give us but a weak representation of the cold which prevails in the world's space. On the basis of certain hypotheses this cold has been attempted to be calculated, and the high figure found of about four-hundred degrees below the freezing point.

Among the aërial voyages undertaken for scientific objects, next to that of Professor Charles, those of the French physicians, Biot and Guy Lussac are the most prominent. The principal cause of their first journey was the fabulous and romantic account which an aëronaut had published about the condition of the atmosphere at great heights.

We may remark here that if clouds fill the air strata, which the balloon runs through, the formation of mist and rain is followed by snow and hail; every second or third, and even more cloud strata placed upon one another, are often separated by a clear aërial landscape. If otherwise the weather is clear, then the moisture falls off as a rule according to the altitude, and at a great elevation there is such a dryness that in the hygrometer, for measuring the moisture, the small hair snaps in consequence of its strong contraction.

The great rarefaction of the air has also an influence on the perception of sound. Air, it is

known, conveys the vibration of sound to the ear of the listener. If, for example, an automatic bell is brought below the recipient of an air pump, we notice the clapper begin striking it, and the sound lessening the more the air is pumped out and at last there is no sound at all.

Thus then, at great heights, the human voice is without sound, and many an aërial traveller can relate in what danger they have been placed when their companion could not understand or hear the pressing call involving ballast or valve.

Finally there is a phenomenon known only in modern times, which throws a peculiar light upon our organism. It has been observed in these altitudes that the human body is electrified in a high degree, so much so that the hair stands up, and the fingers emit sparks; indeed, according to the testimony of good authority, the tension of the electricity causes an almost unbearable irritation, and it is quite possible that one or other of the catastrophes, with which aërial voyages have ended, are partly referable to this phenomenon.

If we here below are protected from such dangers we owe it to the abundance of air surrounding us, which carries off and dissipates the electricity that collects in our body.

In recent times great exertions have been made to arrive at a practical knowledge of the electrical condition of the atmosphere by means of the balloon.

It is of frequent occurrence that in spite of days, indeed weeks of a covered sky, no rain falls, for the reason that the numerous water bubbles floating in the air receive no tendency to collect themselves into larger drops, and as such become precipitated. An American has now made the proprosal to create the tendency artificially, by the despatch of an electrically-charged balloon into the clouds, there to be discharged. The experiment has been carried out a few times with but uncertain success. Yet it is not improbable that the method may be of importance in the future.

If aërial travelling allows the seeker after nature favourable opportunities to study the active forces of nature, it also allows others opportunity to enrich their feelings and ideas in a larger and more fruitful manner.

It ought not to be considered that the participation of the general public in aërial voyaging is a mere amusement of an ordinary kind, even as little as this interpretation could be justified when applied to Alpine climbing. The moment a man leaves his accustomed mother earth, it is calculated to make his heart beat quicker. Even with aëronauts who have made numerous voyages, the same solemn feeling overpowers them just as in their first ascent.

Rousseau, to whom the experience of only mountain tours was familiar, says it seemed to him as if, at an elevation far above "the all-day dwelling-place, every meaner feeling was left behind, as if the soul

in the nearing to heavenly regions partook of their purity." This is a pleasure which the aëronaut enjoys in a more eminent degree than could be attained on any mountain summit however high and open.

The contemplation of the earth's surface, which on terra firma can only be seen piece-meal, is enlarged with the ascent, and from moment to moment the scene becomes more extended, and what was viewed piece-meal at first is now beheld as a collected whole.

There it lies far below, the world's city, and an indescribable dull confused noise is driven upwards in the air. Then the plain unfolds, the rivers and seas, silver glancing, the cornfields of golden hue; then again dark forests and jagged mountains, groups in whose dark valleys the aërial traveller looks far down. Then present themselves in variegated hues, sometimes serene, sometimes gloomy, scenes to the eye, without the slightest bodily movement, floating in the empire of the air in dreamland. If the balloon mounts still higher there is an opportunity of reaching the strata of the cloud veil; the earth disappears from sight and only the broken rays of the sun penetrate the thick magic covering, to the eye of the traveller an image of a vast desert high up in the air. It is self-evident that all these enjoyments are essentially connected with a free aërial voyage with a few quiet companions out of the ranks of the human race. An ascent in the so christened "captive" balloons attached to a long rope, and in the society of twenty or

thirty or more persons, with extremely small space for each and little time, is, comparatively, an enjoyment of highly doubtful value.

The numerous free aërial voyages undertaken for an exhibition of the art, cannot be described here, although it must be observed that those who undertake them show by no means small personal courage. In this class, Blanchard, who was born in 1753 and died in 1802, was the first, as previously stated, who succeeded in the aërial passage from Dover to Calais, and who met with his death in his sixtieth ascent, in the service of science; a similar catastrophe that befell his wife some years afterwards in continuing the business of her husband, for business it had really become. Further and more prominent, still, Green, father and son, Coxwell, and also of our own time, Godard and Nadar, who, through the security they maintained in the ascent and landing, have secured well earned fame, are among those, who from passion or desire, have made ascent with the most probable safety.

If it is sufficient for the application previously claimed for the aërial vessel that it is movable in a vertical direction, and, according to the will of the aëronaut, it is also necessary for other uses to have other appliances for the purpose of moving in a horizontal direction; a problem that is as far from a satisfactory solution now as at any time since the initiation of the art, so far as it may be practicable against the force of ordinary atmospheric wind-pressures.

The greatest height that has been reached is about thirty thousand, feet by Mr. Glaisher, of the Meteorological Observatory at Greenwich, in company with Coxwell. The ascent, undertaken for scientific objects, was made on the 5th of September, 1862. At an elevation of eight thousand yards the thermometer fell to sixty-three degrees below zero. At this prodigious height the cold was so intense that Coxwell lost the use of his hands. In order to descend he attempted to open the valve, but found his hands useless and was obliged, for that purpose, to seize the rope with his teeth. Mr. Glaisher was almost unconscious, even at the height of twenty-seven thousand feet; and both these distinguished men were on the verge of losing their lives in these unexplored altitudes.

Among the dangers of aërial explorations when not guided by great judgment and experience, we may also name those of the ascent of Crocé-Spinelli, Sivel and Gaston Tissandier as an example. The ascent took place on the 15th of April, 1875, with an intention to rise to the highest regions that man could reach. The scientific mission was given to Crocé-Spinelli, Sivel and Tissandier, and the expenses were principally paid by the Academy of Sciences, in order to complete the data collected in the ascent made on the 23rd of March, 1874, by Crocé-Spinelli and Sivel, and in which they had accomplished a voyage of twenty-three hours over the whole of France. In this ascension they had made some important meteorological

determinations. There was a desire to complete them at the greatest elevation that could be reached. It was necessary to establish the fact whether humidity exists in these heights, and what is the proportion of carbonic acid gas. They carried the same scientific apparatus which had been employed on the 23rd of March, 1874, and they departed in the same balloon. Gaston Tissandier was to determine the carbonic acid gas. Crocé-Spinelli was to test the humidity by spectroscopic observations. Sivel, aëronaut by profession, directed the aërial vessel. Only two hours after their departure Spinelli and Sivel were struck down with pulmonary apoplexy, and Gaston Tissandier lay half dead near the bodies. He owed his safety, as he states, to the fact of his falling into a swoon whilst he was floating in space almost void of atmosphere.

The results of this tragic ascent in a scientific point of view are almost nil. Can we hope for better results from ascents to great heights? We do not believe we can. It is wished by many to know the proportion of carbonic acid gas which exists in the air at an elevation of four thousand to twenty-eight thousand feet. Where is the utility of this determination? To recognise the proportion of carbonic acid gas at fifteen thousand to eighteen thousand feet may have a scientific interest; but why repeat the experiment at seven thousand higher? The same reflection applies to the humidity of the air.

It would then be very desirable to renounce experi-

ments as hazardous as useless. We do not see what scientific facts can be gathered at extreme altitudes of our atmosphere where the danger of life is not only imminent, but also the results of all scientific research are likely to be completely stultified by the physical prostration of the explorer in prosecuting it.

CHAPTER V.

MILITARY APPLICATIONS OF BALLOONING.

The first movement attempted to turn aeronautics into an aid for military operations was made by the French government in 1794. The author of this movement may be accepted in the person of a celebrated chemist, Guyten de Merveau, then a member of the National Convention. He proposed to employ balloons, held captive by cords, and in the boat attached to place some competent person to watch the position and movements of the enemy. The proposition was approved by the Comité de Salut, and the first preparations were instituted by Guyten de Merveau and another eminent chemist, Coutelle, who had now joined him in this enterprise. Coutelle, began the preparation of the gas, hydrogen, with a furnace, in which he put a cast iron tube, three feet long and fourteen inches in diameter, which he filled with one hundredweight of sheet-iron clippings. This tube was terminated at each of its extremities by an iron pipe. One of them served to conduct the current of steam, which was decomposed by the contact of the heated metal, the other directed into the balloon the hydrogen resulting from this decomposition.

By reason of many accidents the operation was

very long, yet there was obtained five hundred and fifty cubic feet of gas. The government commission was satisfied with this result and Coutelle received orders to proceed to Belgium and to submit to General Jourdain the proposition to apply balloons to the operations of his army. His opinion was at once favourable. The Republic then founded the Institution of Military Aëronautics, and Coutelle was nominated director of aëronautic experiments, and he established himself in the garden of the little Chateau de Meudon, and connected the scientist, **Jacques Conté** with his labours.

They constructed a silk balloon calculated to carry two persons, and arranged for the filling a new furnace in which were placed seven cast iron tubes. These tubes, nine yards and a quarter long altogether, and the same measurement as previously in diameter, were each filled with four hundred and fifty pounds of iron clippings, which were crushed with a rammer into the tubes. The gas was thus easily and abundantly obtained. One and a half pint of water furnished three cubic feet of hydrogen and only twelve to fifteen hours were necessary to fill the balloon.

The great difficulty was to prevent the hydrogen from escaping through the silk envelope of the balloon. If there had been a necessity for the preparation of gas and filling the balloon every two or three days in the midst of military operations the system would have been impracticable, so that it was important to have the

material of the aerial vessel impervious; an advance in the art not then attained.

This problem, until then not solved, was decided by the chemists Coutelle and Conté, so that they were enabled to retain the hydrogen in the balloon two months, and frequently at the Meudon School the balloons were sometimes three months full of gas.

The incorporation of the Corps of Aeronautics (Compagnie d'Aerostiers) was followed by great activity at several military operations, in aerially reconnoitring the position and movements of the enemy. Conveying the balloon filled from place to place was a work of much difficulty and, at times, of damage to the air craft itself. For this work seventeen men were sometimes told off, each holding one of the ropes, about thirty feet long, hanging down from the balloon, and so drawing it along, very often over serious impediments.

This body always followed the march of the army. Without going over the various incidents of their employment, it may be sufficient to state that after a career of usefulness mixed with some failures, Napoleon, who does not seem to have been much enamoured of aeronautics for military purposes, ordered the school at Meudon to be closed, and all the material to be sold.

Since that period the balloon has been employed by several governments in their war operations, to reconnoitre the position and movements of the enemy. By Russia in 1812, and Austria in 1849, before

Venice; and by Napoleon III. in his Italian campaign, preceding the battle of Solferino.

But the greatest employment of aeronautics, in modern days, was made by France when Paris was besieged in 1870–1871 by the German army. It is known how, during the siege of Paris, intelligence was carried by means of balloons, over the heads of the enemy, and through carrier pigeons the state of the city was transmitted throughout the provinces. The size of the balloons employed were generally of 2000 cb.m. volume, although other sizes were constructed down to 700 cb.m. The first balloon ascended on the 23rd of September, 1870, the last on the 28th of January, 1871. Altogether sixty-four balloons left Paris; five fell into the hands of the Germans, two were carried to sea. These made the ascent at night, and at daybreak were over the ocean, but by unfavourable atmospheric currents were carried on to land again; one reached as far as Christiana in Norway, doing the journey in fifteen hours. One of the sixty-four balloons was furnished with a steering apparatus, but the propeller screw was powerless to resist the atmospheric pressure upon the great surface of the balloon; it fell, after a seven hours' journey, in the department of Marne, far from its destined landing-place. Of all these sixty-four balloons not one succeeded in re-entering Paris, although many ingenious contrivances were suggested for that important object. Manifestly science was taxed to the utmost to discover a means of attain-

ing so vital an advantage to the French people, and in its failure to do so, we may read the prominent weak point in aëronautics. During this memorable siege, the Academy of Sciences were overwhelmed with letters containing offers of inventions for steering balloons, but without any corroborative proof, by actual experiments, of the practicability of the writers' inventions or plans.

However, as **Dupuy de Lôme**, member of the Academy, was in possession, as he thought, of a process by which this important object was attainable, he was commissioned by the Academy, and funds supplied him, to test his method.

The aerial vessel adapted by him was in reality but little different from that of Mr. Henry Giffard. The difference lies in the latter having a steam engine, whilst Dupuy, who feared the vicinity of a furnace near inflammable gas, was content with manual force. This idea of Dupuy de Lôme came to nothing, as the war was ended before his procrastinated plans were put into practice.

It is interesting to note the direction in the flight of the balloons despatched from Paris during the siege.

They were generally sent off in couples, within a few minutes or an hour or two of each other. Taking eight couples so sent off, we find,

1	fell at	Montdierdia	1	fell at	Cremery
1	,,	Nugent Aube	1	,,	Britton Meuse
1	,,	Vignoles	1	,,	Verdun

1 fell at Loire Inférieure	1 fell at Eure et Loire
1 ,, Ferrières	1 ,, Vitry
1 ,, Holland	1 ,, Norway
1 fell into the sea and was impelled on shore again by a change of wind	1 ,, Brittany
1 fell at Somme	1 ,, Cremery.

On the value of balloons, as so-called captive balloons, for military operations, opinions are somewhat divided. There are many difficulties in the way of their successful employment, commensurate with the cost and labour engaged in organising an adequate staff for them, and providing the necessary suitable gas to fill them.

It is probable that the opposed opinions of military men have been formed from accidental differences, arising from the state of the weather, or other causes when they have been personally engaged with the captive balloon for reconnoitring; although unfavourable opinions are entertained by distinguished military men, as to the general employment of the captive balloon for military purposes, yet it is on record that in modern days many signal advantages have been obtained by its use during war. Napoleon III. owed much of his success in his Italian campaign to it. **Nadar and Godard** were engaged to make a recognisance of the enemy's position previous to the battle of Solferino, and the knowledge thus gained was

of essential benefit to the French army. At the battle of Richmond, the North Americans undoubtedly owed their success greatly to the reconnoitring, assisted by a Morse telegraphic apparatus from the aerial craft in connection with the balloon station; the captive balloon being secured by a rope of three hundred to nine hundred feet long. Once, when General Porter was observing the movements of the enemy from a captive balloon, the cable broke and he found himself floating towards the Confederate Army. He at once took measures for making the balloon descend, and fortunately for him it struck a current of air going in the opposite direction, and landed him safely among his own people. During the two days' fighting at Fair Oaks, Mr. Lowe watched the battle from a height of two thousand feet, and was the first to make known the general retreat of the enemy.

A great difficulty in the employment of the balloon for military purposes lies in the production of the necessary gas, which has to be renewed often, and therefore requires an apparatus which must follow the troops wherever they go, so as to have the gas at hand. As it is seldom that balloon stations are in the vicinity of gas works, and as the transport of coal gas in suitable vessels is difficult, even when the vessels are closed with care, hydrogen is preferred. In England the apparatus for gas making for military operations, does not generally exceed six tons in weight, and for the purpose of easy carriage, no part exceeds six hundredweight.

Such apparatus produces per hour some four hundred and thirty cubic feet of gas, and fills a balloon of moderate size in three or four hours. For its production a combustible material on the spot is available. In the defence of fortresses the employment of coal gas is mostly the case; with sieges, however, as in field campaigns, hydrogen is almost exclusively used.

We may assume that in sieges when the nature of the ground permits, ascents at night are practicable, and in the boat of a balloon a concave mirror may be placed for electrical illumination, by means of which the ground is inspected and the works of the enemy reconnoitred. The electric apparatus remains on the ground, and an insulated copper wire in the rope of the balloon is also employed to transmit intelligence. Naturally it is better that the balloon remains in telegraphic connection in order to communicate intelligence immediately.

It is known that Prussia, in 1870, formed in Cologne, two detachments of aëronauts, comprising twenty men, in order to employ them before Strasburg. For this purpose Henry Coxwell was engaged to instruct them in a service which his great experience so well fitted him to do. After the delivery of his balloon, the work of filling with hydrogen was attempted, but owing to the violent winds, and the leakage of the conducting hose, the balloon obtained a lifting force for only one person. It certainly ascended three-hundred and fifty feet, but, owing to stormy winds, no observations

were possible. The detachment was afterwards drawn to Paris, where on account of mist and other unfavourable weather no progress could be made.

The French government has instituted on several occasions inquiries for the purpose of arriving at the capabilities of the balloon for military operations. In 1871, the minister of war appointed a special commission under the presidency of Colonel **Laussebet**, assisted by the distinguished Captains, **Renard** and **Delamore**, for that object. The result of the commission was favourable to the re-establishment of the Aeronautic School at Meudon, abolished by Napoleon, ninety years previously, and to the formation of an efficient body of aeronauts. The commission led to important discoveries in the varnish used for the silk, so as to strengthen it against the escape of gas ; also as to the facilities in landing, with other improvements in connection with captive balloons.

CHAPTER VI.

STEERING POWER.

The problem of steering balloons has engaged the attention of science for the past century without an arrival at any very satisfactory solution. Since the discovery of aeronautics, innumerable schemes have been suggested, as well as tried, in order to be able to steer the balloon horizontally left or right, but yet without any approximate result.

With the steering force of the aërial vessel stands or falls the most important and wide-ranging application of the art; as a public and regulated means of commerce. No wonder since the infancy of the art that this question should have employed the thoughts of hundreds upon hundreds. Indeed, long before the invention of the balloon the idea of a flying machine was an excitement to phantastic heads.

People wished it to imitate a bird and to be supported in the air by personal muscular force, as well as to move in any direction at will. If not to every intelligence the impossibility of this is clear, yet it is practically shown by close scientific examination. In order that a living being may move and be supported in so light a medium, capable of such little resistance, as atmospheric air, a completely changed

relation must take place between corporeal weight, corporeal circumference and muscular force. No other class of the animal kingdom shows with all varieties of detail so general a type of form of body and construction of limbs as the class of bird, and the object, or to speak à la Darwin, the cause, of this harmony is the property of flight. Even the bat reminds us always of the bird.

Theoretical inquiry teaches beyond this that a different organism is required for flight, not only a proportional but even a disproportionate amount of muscular power, and at the same time a proportionately greater length of wing. With small birds the length of wing, even with good flyers, is generally less than the length of body; with large birds it is considerably greater, and on this principle with man it must be at least sixteen to eighteen feet. For this a muscular force would be required, which would put at the outset a weight of twenty-five to thirty pounds on the motor muscles; and in addition no consideration is taken of the changes which enter into the mechanism of the wing with increasing size of body.

Pettigrew in his book "Animal Locomotion," remarks on aërial travelling, and has treated this subject very exhaustively.

Man has in proportion to his weight much too weak muscular force, to carry himself in the empire of the air; and no mechanism avails, no construction of wing however powerful and ingeniously contrived, as

dreamers have imagined, for when the force is irretrievably too weak to effect a desired end, it must remain so, in spite of all aid that does not increase it.

Towards the solution of the problem of balloon steering, it is not useless to consider the means by which we move boats in the water in any direction we please; yet the comparison may be deemed most unsuitable. The characteristic nature of a boat rudder of a wheel or screw steamer, even of a sailing ship which may reach its object by tacking, is that it moves within the limits of two media, of two substances, air and water, and with the condition that these two substances, air and water, possess a very different density and elasticity; that is, upon capacity of resistance, essentially depends the manner of employing maritime means of motion; a paddle-wheel, for example, when it goes wholly in the water, effects nothing, because the work of the lower half of the paddle would be stultified by that of the upper. What applies to the sail would remind us of the boy sitting in the railway coach and wishing to push it along without considering that the fixed point was wanting upon which he could support himself.

The screw, therefore, only remains when transfer into the region of air is considered. Screws, according to their work, are the reverse of the wings of a windmill; whilst these are turned by the current of air, the screw, on the other hand, bores into the moving medium. Then we have as an essential condition for

our purpose that the medium must be in a state of rest or at least in only slight motion. In air, however, this is seldom the case, even if only a moderate wind blows, its force would considerably overpower that of a strong screw, making the work in a great measure illusory. It will show best how powerful is the pressure of the wind when we reflect that it is capable of driving heavy mill machinery, and then that this pressure is greater, the greater the expanse of surface. If we take a balloon of thirty feet diameter and consequently one hundred and fifty square yards of superficial area, and if we bring only a light wind upon it, say at a velocity of three feet in a second, we have a pressure of 44 pounds ; and with a moderate wind of twenty-five feet per second, we have a pressure exceeding twenty-five hundredweight ; and with strong winds, of tens of tons ; the pressure increasing consequently in a much greater ratio. It is clear that the screw, in order to overcome such formidable resistance, must rotate violently and would require steam or other great power. The latter would necessitate an increase in the dimensions of the balloon, and consequently a fresh addition to the opposing pressure. To the balloon itself a motor could scarcely be attached with any really practical use. It must be connected to the boat, and over this the balloon floats so freely that the transference of the force upon it would be very imperfect. Indeed the danger of impulsion increases very considerably, as the air craft would, in a great

measure, lose its equilibrium by this kind of motion.

Notwithstanding all these obstacles, some very good results were obtained in Paris at the beginning of 1870 and subsequently, with the steering of air craft. The most interesting is that of Dupuy de Lôme.

De Lôme's balloon had the form of a thick and proportionately short cigar; its length one hundred and thirty feet and diameter forty-five feet, with a volume of one thousand three hundred cubic feet and possessing a lifting force of fifty hundredweight. Inside the principal balloon was a smaller vessel filled with air, the use of which we already know.

The peculiar form of the balloon has the advantage of ten to twelve times less resistance opposed to it than a spheroid would have under equal conditions. The screw is arranged above the boat, has four wings of silk taffeta stretched over a strong frame, with a diameter of twenty-five feet, and a high velocity of action. When this makes twenty revolutions per minute, the progress is from six to ten feet each second, to which is associated an expenditure of force of thirty kilogram-metres. Four men, with two more, as a relay, are sufficient. If calms prevail the air craft can travel in every direction at will, although at slow speed. With winds less than six to ten feet velocity, it can also go in any direction, but not with equal velocity, and against the wind only extremely

slowly. With winds of more than that force, and such almost always prevail in the higher strata, the balloon can only tack about; that is, in consequence of the addition of its own velocity to that of the wind a certain deviation from the direction of the latter is necessary to attain its object. With a fresh breeze of thirteen feet per second, this deviation amounts to thirty-three degrees on both sides; all points which lie without this space the air craft may be enabled to reach by a corresponding regulation of its screw velocity, all other points are unattainable by it. With a strong breeze, twenty-six feet per second, its progress against the wind is nil, and with a storm the balloon must follow completely the direction of the wind.

We see that the performances of this very ingeniously constructed aerial vessel, provided with an outstretched sail serving as rudder, are very moderate indeed, and it appears that Dupuy de Lôme has not been further occupied with his invention, notwithstanding the grant of 40,000 francs by the French Government for its further presentation. Moreover, Giffard, previous to de Lôme, constructed, in 1862, a similar steering aerial vessel, and when de Lôme expressed his surprise that Giffard had neglected his invention, or rather explained this neglect himself because of unimprovable deficiencies of Giffard's balloon, it is natural to conclude that we shall learn nothing further of Dupuy de Lôme's from the report of the Paris Academy.

The insufficiency of motive power being the principal

cause of the inability to steer the balloon, Henry Giffard made trial of steam for the purpose. On 22nd of September, 1852, this was attempted at Paris. Giffard's balloon, Fig. 1, was of a long form, presenting, by its section, that of the hull of a vessel. Its length was one hundred and thirty-two feet, its breadth in the middle thirty-six feet, and it contained seven thousand five hundred cubic feet of gas. It was covered on all sides, except at its lower part, with a net work, the extremities of which were joined to cords fixed to a wooden horizontal traverse, sixty feet long. This traverse carried at its extremity a kind of triangular sail, connected at one of its sides to the last cord hanging from the net-work, and which held it in the place of a rotary axis.

The sail represented the rudder; it sufficed by means of two ropes, to incline it to the right or left, in order to produce a corresponding deviation in the apparatus, and an immediate change of direction.

In case of a defect in the working, it placed itself in the axis of the balloon, and its normal effect then consisted in doing the office of ball or weather-cock, that is to say, to maintain the whole system in the direction of the wind.

About eighteen feet below the traverse, the steam engine and all its accessories were suspended.

This steam engine was placed on a kind of wooden scaffolding, the four extremities of which were sup-

ported by suspension ropes, and the middle of which, furnished with planks, were for the purpose of supporting the persons as well as the provision of water and coal.

The boiler was vertical and without tubes. It was in part surrounded exteriorly by an envelope of cloth, which whilst utilising the heat from the coal, allowed the gases from the combustion to run off at a lower temperature. The chimney pipe was reversed, that is to say, brought below the platform, from top to bottom, in order not to set fire to the gas.

The draught was effected in this pipe by mean of the steam, which, as in locomotives, issued with force at the exhaust of the cylinder, and which, in mixing with the smoke, lowered considerably its temperature, whilst rapidly projecting this steam in an opposite direction to that of the aerial vessel.

The coal was burnt in a furnace, completely surrounded by a fender, in such a way that it was impossible to perceive, outwardly the least trace of fire. The fuel employed was coke. The weight of the water, independent of the accessories, was two hundred and twenty-five pounds for the boiler, four hundred and ten pounds for the machine, in all three hundred and thirty-five pounds. To obtain the same mechanical effect by manual labour which this motor had in working, it would have required twenty-five to thirty men, representing a total weight of about four thousand pounds; that is to say a weight

twelve times more considerable than the aerial vessel would have been able to carry.

On each side of the machine were two receptacles, one containing the fuel, the other water, intended to replace in the boiler that which escaped in evaporation.

A pump moved by the piston rod served to force this water into the boiler.

This expenditure of water replaced the ballast of the aeronauts. This new kind of ballast, had for effect, that being expended gradually by the disappearance of the water in steam, the balloon was lightened little by little without the aeronaut being obliged to have recourse to throw out sand or to any other means employed in ordinary ascension.

The motor apparatus was placed upon wheels, movable in any direction, which allowed its easy transportation when landed.

When filled with illuminating gas the aerial vessel had an ascensional force of about four thousand pounds distributed as follows :—

Vessel with valve	760 lbs.
Net	330 ,,
Traverse suspension rope, governor and anchor rope	720 ,,
Engine and boiler	340 ,,
Water and coal, contained in the boiler when starting	130 ,,
Planks, movable wheels, receptacles for water and coal, &c. . . .	930 ,,

Rope for dragging, to stop the balloon	180 lbs.
Weight of persons conducting . .	180 ,,
Ascensional force at starting . .	25 ,,

There remains then to dispose of about 500 lbs. represented in the provision of water and coal and ballast.

In the experiment which H. Giffard undertook, he had to vanquish difficulties of two kinds. First in suspending a steam engine below a balloon filled with hydrogen in the most suitable manner, in avoiding the terrible danger which might result from the presence of a fire in the vicinity of the inflammable gas. Secondly to obtain with the screw, operated by steam, the direction of the aerial vessel.

In the first question there were many difficulties to overcome. In fact aerostatic apparatus previously employed were almost always spherical globes, holding, suspended by a rope, a boat containing one or several persons, or some other object, more or less heavy. All the experiments attempted outside of this primitive exceptional arrangement, had taken place—and what was infinitely less dangerous—with small models held captive by the experimenter.

In the absence of all anterior conclusive facts, the inventor necessarily had certain fears of the stability of his aerial craft, in the absence of a keel to the vessel. The experiment assured him in this respect; it proved that the elongated air craft is the only one that could be employed. The same experiment established in the

most conclusive manner that danger resulting from the close neighbourhood of fire and inflammable gas could be completely obviated.

As to the second point, that is to say, of direction, the results obtained were the following:—in an air perfectly calm, the rate of speed in every direction was from six to nine feet per second. This speed was naturally increased or diminished with the velocity of the wind, according as the vessel travelled with or against the wind. In every case the apparatus had the power to deviate more or less from the line of the wind, and to form an angle with this, which depended upon the velocity of the latter.

The experiment took place on the 25th of September, 1852, and, as reported, H. Giffard set off alone from the Hippodrome at 3 p.m. The wind blew with somewhat of violence; the aeronaut did not intend, for a moment, to struggle directly against the wind; the strength of the machine would not have permitted it, but he operated successfully various manœuvres of a lateral deviation, and of circular movements.

The action of the rudder was perfectly satisfactory. The aeronaut had scarcely drawn one of the two ropes of this rudder, when he saw the horizon turn round about him. He rose to a height of four thousand five hundred feet and maintained himself there.

However, night approached and the experimenter could not remain longer in the air. Fearing that the

air craft might not reach land with sufficient velocity, he began to put out the fire with sand, and he opened all the taps of the boiler. At the moment the steam was escaping the balloon was at the greatest elevation it had reached, namely, four thousand five hundred feet.

The report continues to state that the air craft was moved about with much facility, and returned safely to land near Trappes.

It was subsequently arranged that H. Giffard should make about a dozen ascensions with the same steam aerostat. This arrangement, however, fell through, in consequence, as stated, of the Gas Company's inability to supply the necessary amount of gas for filling. And here this steam balloon would seem to have rested, without further demonstrating its capacity for aerial navigation.

Gas engines have been suggested as motors for steerable balloons, and the civil engineer **Hänlein** constructed one, and made a trial of one hour with it in his balloon in December, 1872, at Brünn, where he obtained a velocity of 5·2 inches per second. Afterwards he built a rotatory gas engine for the propulsion of a balloon, which with 2·8 horse-power made 180 revolutions per second, and with which he hoped to obtain such favourable results that when they were fully worked out the problem in fact of perfect steering would be solved. Until the present time, however, the practical proof has not been ex-

hibited. The invention, notwithstanding, still stands patented in the German Empire. The gas for feeding the engine is taken from the balloon and ignited by electric sparks. The eight explosion chambers are placed on the periphery of a wheel, so that the push is tangent to it. The weight of the whole machine and screw and galvanic apparatus is about six to seven cwt.

In addition to the experiment of Dupuy de Lôme, **Helmholtz** has instituted a general theoretical examination of the question for the German government, as to the progress of aërial vessels by means of motors, and has arrived at very slightly encouraging results.

In order to go slowly against a fresh breeze the volume of the balloon must be three or four times as great as the lower immersed part of a large ship of the line. On the firmness of the material of the envelope or sail, there could scarcely be any sensible dependence, and the motor must be so large and be built so strongly that the balloon would be over weighted. It would lead us too far to enter upon all the remaining means and methods, hitherto without results, as to the steering of the aërial vessel. Only one idea deserves to be named on account of its curiosity.

Emsmann, in the year 1858, and after him others, made the attempt to impel the balloon by the force known as the "force of recoil," and by which, for instance, rockets and other fireworks are put into motion. The force would be very great if a reservoir with solid carbonic acid were arranged in connection with the

boat; supposing the reservoir had a suitable position, and it were opened suddenly, the carbonic acid momentarily formed into gas would move the balloon in the opposite direction; a method Jules Verne employs in his "Journey to the Moon."

Unquestionably the principle of steering a balloon in a determined direction through the different air currents or strata lying above one another would be preferable to that one which would require a motor, if the principle could be applied by every aeronaut in all places with some security, a nearly impossible difficulty, as the air currents in the different altitudes have neither the same direction nor the same elevation.

However, we possess no charts of the constant or periodical air currents, of the mean zone, as they are observed in the earth's surface. It is probable that the atmosphere of our latitudes has constant air currents, such as is shown in the currents of the ocean. But up to the present nothing is settled by scientific researches as to the definite direction of air currents.

If we are to accept the report of Charles Renard and A. Krebs, captains in the French army, the problem of balloon steering would appear to be partially solved by them. On the one occasion of their experimental trial, on the 9th of August, 1884, they had a cigar-shaped balloon, thick in the middle and pointed at both ends, and the boat was provided with a screw and

rudder, &c. The dimensions of the balloon were one hundred and sixty feet long; diameter twenty-six feet; volume, five thousand six hundred and twenty-seven feet. The total weight of the air craft was about four thousand five hundred pounds, divided as follows:

Large and small balloon . . .	830 lbs.
Envelope and net	286 ,,
Boat, complete. . . .	1017 ,,
Rudder	103 ,,
Screw	92 ,,
Motor	222 ,,
Scaffolding and Gearing . . .	106 ,,
Conductor	75 ,,
Battery, Apparatus, &c. . . .	980 ,,
Aeronauts	315 ,,
Ballast	506 ,,

The report runs pretty much to the effect that at 4 p.m., when the ascent was made, the wind was "almost calm," that the motor was put into motion and "immediately under its impulsion the balloon quickened its speed and obeyed the least movement of its rudder."

In order not to be entangled among the trees, at the height they were sailing, the fore part of the balloon was pointed towards Versailles, and then afterwards they retraced their steps, "being entirely satisfied with the way the balloon behaved on the road; it having made its return movement with a very feeble angle

imparted to the rudder, about 10°." The diameter of the circle described was about one thousand feet.

A resumé of the experiment is given below, in round figures.

The distance run	4½ miles.
Duration	23 minutes.
Average speed, the second .	16½ feet.
Number of elements employed	32
Electric force expended at the terminals of the machine .	250 kg.m.
Probable return of the motor .	0·70
do. do. screw .	0·76
Work of traction	125 kg.m.
Approximate resistance of the balloon	50 lbs.

With the concurrence of such favourable circumstances, this experiment goes but a little way to solve the problem, under ordinary circumstances, of balloon steerage, which remains pretty much in the same unsatisfactory position it has always maintained, at least in regard to the application of steering apparatus to the balloon. In order to effect this rate, as stated, in calm weather of about twelve miles an hour, there was attached to the balloon an extra weight of some two hundred pounds; not very far short of the total weight of the balloon, boat, &c., when employed for simple aërial navigation.

The morning of the 12th was remarkably fine, but towards the afternoon the wind freshened up a little, to the disappointment of the aëronauts,who were appointed to exhibit the capability of the aërial vessel before the Minister, General Campenon, who, it would appear, insisted upon the trial then and there, against the wish of the aëronauts, who deemed the wind to be unfavourable for the experiment.

At a quarter to 5, the balloon was detached from its ropes and rose slowly, directed in its course in a north-easterly direction by the force of the wind. The screw was put into operation and the head of the aërial vessel pointed towards Chalais. For ten minutes it held a stationary position without nearing Chalais, and as the aëronauts could not land among the trees there, it was necessary to extricate themselves from their situation "coûte que coûte." The captain touched a commutator; the intensity of the current increased and the aërial vessel began its movement towards Chalais, when according to the report, "Tonnerre de Brest, the dynamo is getting too hot," exclaimed Captain Krebs, "Stop! or everything will be in a flame."

The current was "stopped," and it appeared only in time as the current was too strong for the machine.

The screw ceasing to turn, the balloon was dragged by the wind and was seen to disappear behind the wood of Meudon and finally landed at Velizy, about three miles and a half from Meudon.

At the moment when the motor ceased to act, a signal informed the body of sappers engaged in this service that the balloon was going to land. Some of these soldiers set off "au pas gymnastique" and found it at Velizy, whence they towed it to Chalais by means of their guide ropes. It was curious to see the great mass towering above the trees as it was being towed along in all its undiminished rotundity. The fact of its not landing at the place it started from created much surprise among those who had looked upon the ascent of the 9th August as solving the problem of a steerable balloon.

In all these experiments the French Government has taken a direct initiative, and has provided the means for what is intended, in fact, to be associated intimately with their military system.

This may account for the mystery observed by the officials connected with these operations, and their unwillingness to let the public see the details of their experiments.

If it is, according to experience in the present day, impossible to steer a balloon against a considerable current of air, the other question comes to the front whether it is not possible to solve the problem with the help of the wind itself. So long as we know so little of what goes forward in the atmosphere, or indeed know nothing at all, we cannot think of attempting to carry out this idea just now. Meteorology is as yet incompetent to satisfy demands of this kind.

Yet at least we know that in the atmosphere two opposite air currents are continually formed over one another, polar below and equatorial above.

The revolution of the earth round its axis turns the two currents towards the west, relatively a little to the east, and the overlying places of both currents, one of which rises more and more, whilst the other sinks more and more towards it, show in the mean altitudes a great versatility of currents. Thus it happens that the air balloon as it passes through a part of the mean zone, ascending, goes through every possible direction of wind. With the help of these currents we may *perhaps*, particularly if we get to know them more intimately, be able to establish a regular connection between the places upon the air passage.

Nevertheless, the spirit of discovery animates many who are interested in the only great problem affecting a practical use of the balloon as a means of regular and reliable intercourse between places. France, the birthplace of aëronauts, would appear not at all disposed to desert her offspring, and permit all her labours to become a blank. Thus the problem of balloon steering would seem as earnestly to engage her attention as ever, in spite of the very many failures of distinguished men. There are so many "ifs" involved in the innumerable plans and suggestions made for the solution of this hard task that it is difficult to make a choice. "It is not impossible," says one

English writer, "that by means of a propeller worked by *adequate* power *supplemented* by sails which can be adjusted at varying angles, a balloon may be guided to a certain extent on an aërial sea; but it must be confessed that at present no one has succeeded in doing so." Here is one "if" completely nullified, not only by past experience but by the confirmatory evidence of one of the leading laws of physics.

In order to defeat atmospheric resistance various forms of balloons have been suggested or tried at different periods from "eggoons" to "prolate spheroids," but the one form has been productive of no greater benefit than the other.

CHAPTER VII.

PRESENT STATE OF BALLOONING AND RECENT PROPOSALS FOR STEERING BALLOONS.

THE experiments made under the special commission instituted by the French Government, extended to the employment of captive balloons and to steerable balloons. The impermeability of the envelope, for which the best silk is used, was attained in so perfect a manner by Renard and Delambre, by means of a varnish discovered by them, that the balloon retained its ascensional force for months without any perceptible diminution.

In order to protect the captive balloon from injury through gusts of wind, a kind of kite was successfully designed by Petier, to conduct the pressure of wind in the direction of the anchor cable.

The latest invention of the French aeronauts is the production of momentary photographs within brief periods of suspension; which has attained such a degree of developement as to enable an observer to take in the whole ground, with the positions of the troops, in one photograph, which can then be transmitted to the officer in command.

English experiments led to the appointment on the 1st of April, 1879, of a balloon company under the

direction of Colonel Nobel. Major Templer is one of its most talented officers, whose distinguished abilities have made him generally known. The numerical strength of the company is small, because it is proposed in case of a war to unite it with the Field Telegraph and Signal Corps, and then to form several companies, each of which should have the management of two balloons. Whilst in France the government are engaged with the experiments of steerable balloons on Dupuy de Lôme's principle, in England the preference is given to Green's system, developed by Major Templer with successful results.

With the captive balloon very satisfactory results have been obtained. On the 18th of November, 1879, the military balloon "Saracen," was filled at Woolwich with four thousand cubic feet of gas in presence of a great number of distinguished officers. The balloon was secured on a waggon purposely constructed, and, under the superintendence of Major Templer and Captain Elsdale, it ascended to a height of two hundred feet. With the employment of a second anchor rope, containing telegraph conductors, communication was successfully established, thus affording proof of the useful capacity of a captive balloon.

Germany has taken a direct interest in aeronautics since the aerial voyages from Paris, during the siege in 1870 and 1871. It is shown practically, in the formation of societies for the advancement of the art. In Berlin, such a society, under the presidency of

Professor **Angerstein**, has been formed, and received encouraging support from Field-Marshal Moltke, who imparted to it a prospective military status. However, the labours of the society, up to the present, do not exhibit any practical results. The splendid, but unsuccessful, experiments at Charlottenburg are without significance, yet should not discourage, as any person acquainted with balloon experiment could expect no other result.

Our own Aeronautical Society, too, indebted for its well-being and success to the indefatigable labours of its energetic Honorary Secretary, Fred. W. Brearey, F.S.Sc., has done much to advance the cause of the science; and something useful may be expected from its forthcoming exhibition to be shortly held at the Alexandra Palace. In the instructions or suggestions issued to intending exhibitors, it is worthy of note to learn that, "As it is scarcely expected that any aeronaut will claim to drive his balloon against a wind of greater velocity than that by which his balloon can be propelled, but may be able to deflect it considerably from the wind's course, the place of ultimate destination will be determined by the set of the wind at the hour appointed. But if the more ambitious attempt should be desired, then accordingly the goal will be arranged."

Upon the production of a useful motor rests the future of the free balloon, which is a technical problem not yet solved, but the solution of which is only a question

of time, to be found, we hope, at no distant date, in the domain of electro-technology.

Recent Proposals for Steering Balloons.

Gaston Tissandier brought forward during the Paris International Exhibition, in 1881, his small balloon driven by electricity, the screw of which was a framework covered with a silk stuff. In the experiments the balloon attained a velocity of three metres per second, with an expenditure of one kilogrammetre on the shaft of the screw. From that time forward Gaston Tissandier laboured with his brother Albert in the construction of a larger balloon. He first tried to produce a chromic acid battery, as he felt convinced by his experiment, that this could advantageously replace accumulators. He endeavoured, afterwards, to improve the dynamo-electric motor, and make a workable apparatus for the production of hydrogen. Albert Tissandier, on the other hand, utilised his knowledge as architect in the construction of the peculiar long balloon, its covering and the boat. The experiments were carried out in the workshops at Paris, Auteil, constructed for that purpose.

The first electrical balloon, Fig. 2, resembles in its form that of Giffard's and Dupuy de Lôme's, and measures in length twenty-eight metres, from point to point, and has, in the middle, a diameter of 9·2 metres. At its lower part it has a keel-shaped piece, which ends in a self-acting valve. The

tissue is made of percalin, rendered impermeable by means of an excellent varnish manufactured by Arnoul, in Saint-Osen-l'Aumone. The balloon has a volume of one thousand and sixty cubic metres; the covering is formed out of bands which are sewed firmly together upon long strips, and are thus maintained in their right geometrical position. The bands retain perfectly the expanded gas and allow of no "starting out," as net meshes do. The suspended covering is fastened to two pliable supports which run from point to point along the sides of the balloon, following closely the form of the latter. These supports are constructed of thin laths of walnut wood, and bamboo sticks, and are joined together with silk bands. At the lower side of the suspended covering the triangular-shaped cordage runs together, and ends in twenty bearing ropes, joined together in groups of five to the four corners of the boat. The boat (Figs. 3 and 4) is built of bamboo sticks, which are fastened together with cord and copper wire covered with gutta percha. The lower part of the boat is of planks of walnut wood, and carries a bottom of willow plaiting. The bearing ropes pass completely round the boat; they are plaited at the bottom, and provided with a caoutchouc covering, which is intended to protect the cordage from any unforeseen accident from the acids in the filling of the batteries. Two metres above the upper part of the boat are the bearing ropes, bound together by a horizontal crown of cordage. To this crown, which,

by the way, is intended to effect a regular division of the weight in descending, are secured the ropes necessary for landing, also the guiding rope, and anchor rope. The rudder is formed of a large surface of unvarnished silk, which is held fast at its lower side by a bamboo, and likewise fastened to the crown.

The weight of the entire balloon amounts to 2,670 lbs., namely, 375 lbs., the balloon and its valves; 154 lbs., the suspended covering, with rudder and bearing ropes; 55 lbs., the pliable side-supports; 220 lbs., the boat; 616 lbs., the motor, the screw, and batteries, together with the liquid necessary for the work for two hours and a half; and 110 lbs. for the landing arrangements, such as the anchor and conducting rope. With 330 lbs. for two persons, and the instruments; and 910 lbs. of ballast.

The apparatus for propulsion consists of a screw, contrived by **Victor Tatin**, with two wings, measuring 2·85 metres in diameter; further, a Siemens dynamo-electro machine, of the smallest weight; finally of a bichromate battery of especially light elements. The metal nave of the screw is hollow, and is supported by two long bars of good, dry pine wood. The screw is so very carefully made as to weigh only 14 lbs.

The dynamo machine has four electro magnets, and fifty-six divisions of the armature, which is very long in proportion to its diameter. The brushes are reversible. The machine weighs only 120 lbs., and can deliver one hundred kilogram-metres.

Each of the six divisions of the four ebonite boxes of the battery contains eleven carbons, each of one hundred and fifty millimetres height, and eighty millimetres in breadth, three millimetres thickness, and ten somewhat smaller zincs, of 1·5 millimetre thickness, which last three hours. The zinc plates are perfectly amalgamated. Each division has underneath a small ebonite tube connected with a conduit, from which a caoutchouc tube leads to a large, very light ebonite cup, which is lifted over the battery by means of a cord running over pulleys, when there escapes from the cup the solution of chromic acid into the battery boxes. The four boxes contain each thirty litres of fluid. The twenty-four divisions are electrically connected in "series"; the connections produced through the conduits of the divisions or elements of each box are not injurious, because the resistance of the fluid is very great.

G. Tissandier is said to have produced hydrogen for the filling of this balloon from iron and sulphuric acid. The iron is placed in cylinders, six metres high, which are built of eight single (forty-five cubic metre, or 1,600 cubic feet) stone-ware pipes, cemented with a composition of melted sulphur, rosin, tallow, and pulverised glass. The sulphuric acid, mixed with three volumes of water, passes through the pipe A, Fig. 5, below on to the iron, whilst the solution of sulphate of iron that is formed flows off through the pipes B and C. The hydrogen developed ascends through pipes made of a combination of lead and copper, and escapes sideways,

through the pipe T, to a wash-apparatus, and to two scrubbers E, filled with lime.

In the glass globe H, there is a thermometer and hygrometer. The apparatus delivers hourly a constant quantity of three hundred cubic metres (=10,600 cubic feet) of hydrogen.

Renard and **Kreb's** balloon, as previously mentioned, has an elongated form and according to the drawing (Fig. 6) is more slender than that of Tissandier, but not so symmetrical, in so far as the front part is notably of a greater breadth than the back part. The boat is hung as nearly as possible to the balloon and is of very great length. Hence the form of the balloon is very stable, and to this circumstance may be ascribed principally the success, from the practicability of employing, for the first time, such an elongated aerial craft. In opposition to Tissandier, the stiff steering rudder was employed on the boat itself, and the screw transferred to the front of the boat. The length of the balloon is 50·42 metres, its diameter 8·40 metres, whilst its total capacity is one thousand eight hundred and sixty-four cubic metres, or 65,700 cubic feet.

The first favourable result of the experiment of Renard and Krebs appears to have turned the attention of French engineers to aerial craft. In the *Genie Civil*, for 1884, Vol. 5, page 334, two new proposals are promised immediately for the construction of navigable balloons.

The first, by **Duroy de Bruignac**, concerns the more

advantageous employment of the screw, so that its direction of force does not merely pass near the middle point of resistance, but goes through it. For this object it is recommended instead of one balloon to arrange two balloons next to one another, in order to bring the screw shaft between them.

The other proposition refers to the application of compressed air, and is derived from **D. Stapfer**, of Marseilles. Considering, for example, a Whitehead torpedo, weighing only 770 lbs., and performing four horse-power of work in fifteen minutes, the author comes to the conclusion that compressed air may provide a very suitable motor for a balloon, especially for military purposes, and proposes to compress, in a cylinder of about twenty metres long, and thirty-six decimetres wide, of five millimetres thickness of wall, a quantity of two thousand litres of air, to fifty to sixty atmospheres; and to operate a torpedo engine placed to drive an air screw.

The weight of this cylinder with engine, boat, and with air of suitable tension, would amount to two thousand four hundred and thirty pounds. The advantage would consist in the cylinder, as it is separated into two parts, being easily transported, and the apparatus for filling could also be easily and conveniently worked when driven by an engine of two horsepower. A further advantage would consist in the fact that this cylinder would afford a good support for an elongated balloon.

It is manifest that, owing to its great weight, the apparatus for the production of hydrogen, used in filling a balloon, offers an important obstacle to an extended employment of the steerable balloon in military operations in the field: and Stapfer, therefore, assumes that the army would be satisfied in the meantime, for reconnoitring purposes, with a small balloon of eight hundred cubic metres (= 28,250 cubic feet) capacity and filled with illuminating gas.

There is even another balloon mentioned, that which **Gustav Koch** has completed as a model of one hundred and forty cubic metres capacity, and exhibited in Munich, Stutgart, and other places. This balloon is of a cylindrical form, with half spherical ends. For driving apparatus, two screws having four wings, are arranged as near as possible to the balloon and below it, on a framework joined to the upper part of the boat. For rudder, a triangular sail is employed at the back part of the balloon, and is guided by cords from the boat.

In spite of the small size of the balloon, its ascensional force is sufficient to carry a boy four years of age, who turns the two screw wings with moderately quick rotation, and, notwithstanding the unfavourable form of the balloon, a velocity of about one metre per second has been attained. With this arrangement the balloon obeyed the rudder very satisfactorily in the experiments hitherto instituted, in certainly restricted areas. For a larger balloon, constructed upon this

MAJOR BUCHHOLTZ' TABLE.

NAME.	GIFFARD.	DUPUY DE LOME.	HAENLEIN.	TISSANDIER, 8 Oct., 1883. 25 Sept., 1884.	RENARD-KREBS 9 & 12 Sep. 1884.
Length, metres...............	44	36·12	50·40	28	50·42
Height, metres	12	14·84	9·20	9·20	8·40
Capacity, cubic metres......	1600 (about)	3454	2408	1060	1864
Ascending power, kilog......	1800	3799	2629	1240	2000
Motor, with accessories ...	320 kg. 3u. 350 kg.	1050 kg. 204 kg. 8 men[1] =1u.	537 kg., 3·6u.	280 kg., 1·5u.	652 kg., 8·5u.
Diameter of screw, metres...	3·4 (mean)	9 (mean)	4·6 (mean)	2·85 (mean)	7 (about mean)
Number of revolutions	110	25–27	90–180	120	46
Velocity, metres per second.	2–3	2·60	5·20–10	3–5	5·50–9
Total weight, in kilos, per H. P........................	600	3000	730	500	235
Weight of motor per H. P.	290	12000	146·4	186	77

[1] The power of a man at the crank is estimated at 6·4 kgm.

plan, electricity as driving force is intended to be provided, or a gas engine fed by the gas taken from the balloon. In the last case the inventor hopes, by the employment of a rotating gas motor, to be able to reduce the weight of the engine to about six kilograms, or say 13 lbs., per kilogram-metre.

Major Buchholtz, in the "Electrotechnische Zeitschrift," has given a table, reproduced on the preceding page, that includes all the principal trials in sufficient detail. He remarks that, from observations made at Berlin from 1878 to 1883, the velocity of the wind did not exceed five metres per second during 254 days of the year; consequently, the velocity actually obtained with balloons would render them serviceable during the greater part of the year.

CHAPTER VIII.

THE COST.

WITH a problem of such great difficulty, we must, at least, leave out of consideration the question of relation between the means and the results obtainable. If aerial navigation is intended as a means of trade, then, perhaps, a greater velocity than it gives at present would be proposed, because the question is not really either as to security or to cheapness.

As to the point of cost this is manifestly very difficult to consider, or even to make a rough guess at, and it would appear that no one has seriously ventured to do so. The principal question is, how long can the same filling of gas last. This is one that cannot be answered, because it depends upon the air currents which, by their nature, determine the vertical movement of the balloon, and upon the degree of imperviousness of the envelope material. Up to the present time, no adequate material, impervious to hydrogen or illuminating gas, has been found, and thus there would be continuous loss in gas and temporary removal of it; even when employing Meusnier's air-bottle (which makes the opening of the valve unnecessary) it would be unavoidable. Yet regarded from this point itself, aerial navigation would be placed in a very costly position as a

means of commerce. We may assume that a balloon to take twelve persons, requires almost thirty-three thousand feet or about ten thousand cubic metres of hydrogen. An equally large balloon filled with illuminating gas would only be able to carry five or six persons. Each passenger, therefore, would require, in round numbers, 200 cubic metres of illuminating gas, which would cost about thirty shillings for each passenger.

If we add to this the cost of the silk material, which frequently enters into a thousand pounds and more, the cost of the boat, labour in filling and all other expenses, and consider that according to all experience, and even admitting important improvements, a journey with the same amount of gas will scarcely exceed, on an average, three hundred miles, probably not half as far, then the answer to the question of cost is easy. Manifestly aerial travelling will never be cheaper than by railway or steamboat.

There is a question about the speed. The locomotive is much younger than the balloon, and now its speed may be assessed at thirty to forty miles an hour.

The steamer is a formidable rival, in the point of speed, even to the locomotive, when we observe the passage between New York and Liverpool is performed within six days and a few hours, and with future scientific progress it may be in four or five days.

It would be venturesome to assert that aerial navigation has no future, looking to what it has accomplished

during the past century. Nevertheless considering the wonderful strides art and scientific progress have made in later years, it is quite within the scope of discovery to contrive some appliance partly to effect a more practical solution of the difficult problem of balloon steering.

Hitherto, however, ballooning shows only a moderate, certainly not a great progress.

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